1964

The Economic Importance of Fungus Diseases of the Tree Fruits in the Wapato Area

Rodney O. Phillips
Central Washington University

THE ECONOMIC IMPORTANCE OF FUNGUS DISEASES OF THE TREE FRUITS IN THE WAPATO AREA

A Thesis

Presented to

the Graduate Faculty

Central Washington State College

In Partial Fulfillment

of the Requirements for the Degree

Master of Education

---

by

Rodney O. Phillips

October 1964

APPROVED FOR THE GRADUATE FACULTY

_____

Marshall W. Mayberry, COMMITTEE CHAIRMAN

_____

Dan Wilson

_____

Gerald Moulton

ACKNOWLEDGMENT

I wish to express sincere appreciation to Dr. Marshall Mayberry, Chairman, Dr. Dan Wilson, and Dr. Gerald Moulton for serving on my committee.

I also wish to thank Mr. James Ballard, Yakima County Extension Agent, and growers of the Wapato area for their help and advice in gathering the materials for this thesis.

TABLE OF CONTENTS

LIST OF FIGURES

FIGURE PAGE

CHAPTER I

THE PROBLEM, PURPOSE, AND LIMITATIONS OF THE PROBLEM

I. THE PROBLEM

Statement of the problem. It was the purpose of this study to (1) determine which, if any, fungus diseases were affecting tree fruits in the Wapato area; (2) determine what control measures are being used against the diseases; (3) determine the costs for control of the diseases, and/or replacement of affected trees.

Importance of the study. The production and sale of tree fruits is basic to the economy of Wapato. The threat of fungus diseases to these fruits should be the concern of all.

If this study can bring about a greater awareness by lay persons and fruit farmers of the economic loss to an area where proper control measures are not used, it will have been of some benefit.

Limitations of the study. This study has been limited to the fungus diseases prevalent on tree fruits in the region served by the Wapato School district. The cost factors were limited to control programs and tree replacement.

CHAPTER II

REVIEW OF THE LITERATURE

The aim of any study is to become better acquainted with a specific problem. The writer should determine if the problem is real and if others are aware of it.

A study involving a specific area should include a background which gave rise to the problem. A resume of the development of the Wapato area and its economic pattern will provide this for the reader. Historical references point out the interrelation of plant diseases and man.

I. THE WAPATO AREA

Wapato is a part of the lower Yakima Valley, located in Central Washington. The Yakima River flows through the area separating the hills from the flat bottom land.

Agricultural Development

The Federal Bureau of Reclamation began an irrigation project at Wapato in 1913. This was to change a dry desert area into the lush agricultural region of today. Ninety thousand acres in the Toppenish-Wapato vicinity were put under irrigation with the ultimate goal of

120,000 acres (23:4). In 1954, Yakima County boasted 270,000 acres under irrigation (23:3).

The Economic Pattern

The combination of fertile irrigated lands and ideal temperatures for plant growth have created an economy completely dependent on various types of agriculture.

Tree fruits are a major product. Others are mint, sugar beets, hops, row crops, seed corn, alfalfa seed, and cattle. There is no other industry in Wapato that is not economically dependent upon agriculture. A county wide survey of 1954 showed that one-third of all income in the valley came directly from agriculture (23:1).

II. THE INTERRELATION OF PLANTS AND MAN

The interrelation of plants and man is not always benefical to man. Fungus disease epidemics, resulting in famine and emigration, have become a part of the history of many countries.

Destructive Epidemics

Ireland, in the middle of the nineteenth century, depended on the potato crop for their basic food supply. The two years 1845, and 1846, saw almost complete destruction of this crop by a fungus disease, late blight of potato. From 1845 to 1860, one third of the population of Ireland

was lost. Of these, 1,000,000 died of starvation and malnutrition, and the other 1,500,000 emigrated (22:5-6).

Some destructive epidemics of fungus disease of the North American continent, would include chestnut blight, first reported in New York City in 1904 (7:477), and white pine blister rust first reported at Geneva, New York, in 1906 (12:453).

It has been estimated by the United States Department of Agriculture, that the annual loss from plant diseases in the United States is $3,000,000,000 per year (22:3).

III. PLANT DISEASE STUDIES

The continous population growth within the United States dictates, that enemies of food production be eliminated. The combined efforts of industry and agriculture are directed toward this end.

Effective control measures to protect our crops from fungus diseases are being worked out be many agencies. J. R. Magness (11:23) writes, "The chemical companies have largely contributed the new and highly effective insecticides and fungicides now used for pest control in orchards."

The United States Department of Agriculture has experiment stations throughout the United States. Eight

of these stations are located in the state of Washington; the main station being located at Washington State University, Pullman (16:38).

The individual farmer eventually bears the cost of this search for new materials, and the cost of newly developed programs. J. R. Magness (11:23) states that "In the eastern states, particulary, the new materials have not resulted in fewer sprays, and in most cases the newer materials are more expensive, so the total spray program is costing more than in the past."

Various bulletins outlining the costs of fruit production are available from the Agricultural Extension Service. The cost figures for labor and spraying do not itemize costs involved in combating particular diseases or insects. Crop losses due to disease and insect injury have not been mentioned. This presents a static and unreal picture of fruit production.

CHAPTER III

METHOD OF INVESTIGATION

The purpose of this study is to investigate the fungus diseases known to be present in the orchards of Wapato.

To determine which fungus diseases of tree fruits were of the most economic importance it was necessary to interview extension agents, chemical company field men, and growers. Library research was done to study disease cycles and symptoms. Photographs were taken to record visible evidences of the diseases.

Extension Agents

The interview of county extension agents was used to help locate diseased orchards and to confirm photographic evidence. Pathologists of the Prosser Experiment Station provided additional confirmation of photographic evidence.

Chemical Companies

The cost of spray materials and commercial application rates were obtained from chemical companies and their field men.

Growers

Twenty five growers of the Wapato area were interviewed. All had ten or more years experience as a fruit grower. The labor requirements, tree loss, and tree replacement figures were provided by the growers records.

Photographs

A thirty five mm Zeis Ikon Contaflex camera was used to obtain photographic evidence of the diseases. An additional lens, f=o.5 m, was used when more detail was desired.

The photographs were printed in 3½" x 5" size, from Kodacolor II film.

Presented in this study are five diseases determined by this writer to be of major economic importance. One chapter will be devoted to each disease.

Some minor diseases will be given mention in relation to certain tree fruits or having the same pathogen as the disease being presented.

CHAPTER IV

FIRE BLIGHT

The pathogen causing fire blight is not considered a true fungi, but belongs to the division Schizomycota. The importance of the disease led this writer to take the liberty of including it in this study.

Cause and Effects

Fire blight is caused by the short rod-shaped bacterium Erwinia amylovora (20:108). The infection usually starts at the blossoms, working down the pedicel of the bloom, into the spur and down the twigs and limbs in the cambium region just under the bark. As the disease progresses down the tree, the limbs turn dark brown or black, and the leaves take on a scorched appearance. Droplets of bacterial ooze, milky or amber colored, may develop on the affected parts, especially in warm humid weather. Most infections occur when the blooms are full and the temperatures range from 65°F. to 80°F. (15:3).

Figure 1, shows an infected limb removed from a Bartlett pear tree. The limb shows the typical darkening of the bark and the scorched appearance of the leaves. Unless these limbs are pruned in the fall, the leaves

will remain on the tree until pruning time in the spring. Usually these limbs are removed before September to eliminate the continued growth of cankers (15:3).

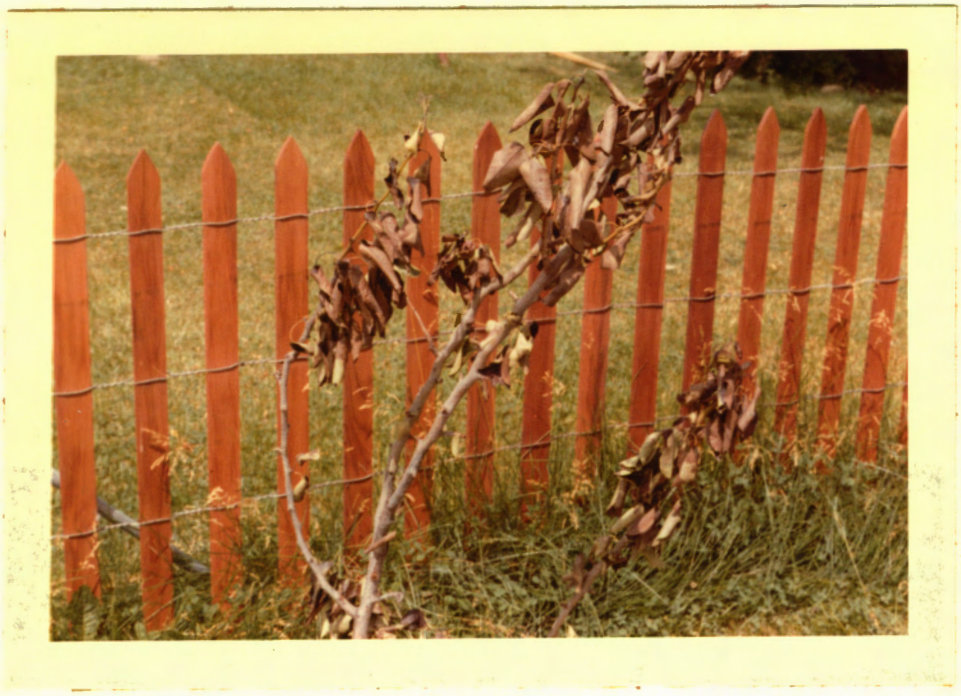

FIGURE 1

SCORCHED APPEARANCE OF LIMB AND LEAVES
THAT ARE INFECTED WITH FIRE BLIGHT

Cankers may form on infected limbs or trunk of the tree. Overwintering of these cankers provide inoculum for spring infection. Infection does not occur until after the cankers start to ooze in the spring. Rains wash the bacteria down the tree, or splash them onto adjacent trees. Some bacteria are also carried in the wind blown droplets of water for considerable

distances in the direction of the prevailing winds (15:3).

Figure 2, shows infected blossoms on a Bartlett pear tree. These infected blossoms will soon drop off,

FIGURE 2

FIRE BLIGHT OF BARTLETT PEAR BLOSSOMS

and the disease will continue on down the spur into the limb. The appearance of the disease in this early stage of infection makes it difficult to immediately identify the disease.

The bacterial disease caused by Pseudomonas syringae will show similar effects on pear blossoms. This disease is called false fire blight. The disease does not spread

into the limbs, but stops at killing the spurs. In this way the disease can be easily identified, and not be confused with Erwinia amylovora (15:8).

Figure 3, shows fire blight in the fingerling fruit, and proceeding past the spur into the limb.

FIGURE 3

FIRE BLIGHT EFFECTS ON FRUIT

Trees that were infected the previous season and are now showing second year characteristics are easily spotted in the orchard. They are usually identified by the light color and the sparseness of the leaves. Many of the branches have been damaged in the cambium layer and the tree has an unhealthy appearance. Many growers will leave

these trees in the orchard in hopes that the trees will repair damaged tissue and profitable recovery will be made. Figure 4, shows the typical appearance of a tree that was infected the previous season.

FIGURE 4

SECOND YEAR FIRE BLIGHT

Controlling the Disease

Control of fire blight is quite costly and requires constant vigilance. Pears, particularly Bartletts, have a tendency to produce a secondary bloom in May, June, or even later (15:3). High humidity during these periods may cause blight to develop in these blossoms. These blossoms have to be picked off as many as three times during the

growing season. Figure 5, shows second bloom in mid-June. Second blooms had been removed from this tree early in May.

FIGURE 5

BARTLETT PEAR TREE WITH SECOND BLOOM

Blighted limbs should be removed as they are found. To prevent excess regrowth the limb removal is not done until mid-July or early August (18:13). To prune before this time can cause added infection. The pruned limbs may contain bacteria which can be spread from one tree to another on the pruner's tools.

One of the growers interviewed had pruned in late June. His pear orchard the previous year had a high per

cent of infection. He expressed concern that the pruning might result in more new growth of second bloom, but had not realized that pruning at this time could easily spread the disease.

Figure 6, shows two lesions on the main trunk of this five year old Bartlett pear tree. These lesions

FIGURE 6

FIRE BLIGHT CANKERS THAT OVERWINTERED ON THE TREE TRUNK

are the overwintering cankers, that have provided a source of inoculum for spring infections. When warm weather comes in the spring, these cankers swell and break through the bark. The yellowish or milky material

oozing from these cankers can be spread down the tree quite easily by rains or sprinkler irrigation. An examination of the canker should be made to determine the extent of damaged tissue underneath. Many such cankers will dry out and die late in the growing season. Others may have to be scraped and painted with a disinfectant. The spray schedule to control infection of blooms is sometimes held off until these cankers become active (15:6).

Figure 7, shows where a lesion has been cut into on the lower main trunk of a four year old Bartlett pear tree.

FIGURE 7

EXPOSED FIRE BLIGHT CANKER
SHOWING RED STAIN

It is apparent by the reddish stain in the cambium layer that the infection is about to girdle the trunk. The following spring this tree will not leaf out properly and will be similar in appearance to figure 4, page 12. Many times during hoeing operations around trees the bark is injured. Heavy rains or sprinkler irrigation may wash bacteria down the tree to these injuries.

The tree shown in figure 8, was sawed off about fifteen inches above the ground in the fall of 1962.

FIGURE 8

BLIGHT FREE NEW GROWTH
FROM STUMP

Since that time new limbs have grown, which appear to be free of the diseas. The main trunk or limbs should be pruned back at least twelve or fifteen inches below the infected areas (18:13). This gives a wide safety margin and also reduces the chance of bacteria getting on the tools being used for pruning.

Economic Importance

In this study four ten acre plots were used to show the costly effects of fire blight on pears, and the expense involved in its control.

The removal of second bloom required the labor of two men for six days on each ten acre plot. This represents ninety-six hours of labor at $1.25 per hour. Three bloom removal operations were necessary. The removal of blighted limbs required eighty hours to complete the four ten acre plots. The cost of second bloom removal was $36.00 per acre, and limb removal $2.50 per acre.

Copper sprays or dusts are put on the orchard to prevent new infection. Three applications during the growing season and a after-harvest application are desirable (18:14). Spraying operations at commercial rates costs the grower $5.00 per 400 gallon tank. Most spray schedules call for a 600 gallon per acre application

which would cost $7.50 per acre. If a grower has his own equipment the cost is $3.00 per tank, or $4.50 per acre, plus the cost of a driver. The type of trees and landscape will affect the time required for spraying. The four ten acre plots studied were sprayed at three tanks per hour. Twenty hours of spraying were needed to cover the forty acres. Driver labor costs were estimated by the grower to be sixty-five cents per acre.

Spray materials such as tri basic copper sulfate are applied at three pounds per acre. The cost is fifty-seven cents per pound and $1.71 per acre. Total spray application costs would be $6.85 per acre for each application. In heavy rainy seasons as many as seven sprays have been applied.

The replacement of trees is dependent on the extent of infection. This ten acre plot, figure 9, was hard hit in 1963. One hundred eighty of 1,040 trees five years old had to be replaced. This required one hour labor per tree, plus one hour per acre for tractor use. The cost of Bartlett pear trees for planting is ninety cents each. The replacement costs on this ten acre plot was $387.00. The other three ten acre plots considered here had very little tree replacement, less than two trees per acre.

Many of the growers interviewed by this writer did not practice all of these controls. Some felt the costs

involved were too high or that it was unnecessary. These growers, however, had never experienced heavy infection for two consecutive years.

FIGURE 9

TEN ACRE PLOT OF FIVE YEAR OLD
BARTLETT PEAR TREES SHOWING
TREE REPLACEMENT

Historical

Fire blight is native to North America and thought to be present on wild crab apples, before colonization of the continent began. It was first reported in New York in 1780, and was called frozen sap, sun scald, or electric charges. Fire blight is known to affect about eighty

species of the rose family. In 1878 a bacterium was first implicated as the causitive agent. In 1891 it was discovered that the bacterium could be insect transmitted (6:137).

C. Emlen Scott reports that Fire blight wiped out pear orchards in the San Joaquin valley and southern California at the turn of the century (14:678).

The disease has been prevalent in Washington for about fifty years. It is particularly common in Yakima, Chelan, Benton, and Walla Walla Counties at lower and moderate elevations (15:1).

CHAPTER V

CROWN ROT

This disease cannot be eradicated, so control is the growers only weapon. When the proper conditions are present in an orchard, the soil inhabiting fungus, becomes active and attacks the trees. The disease may not show itself for several years, depending on the weather (3:139).

Cause and Effects

Crown rot is a root disease caused by the fungus Phytophthora cactorum. The fungus is favored by high humidity. It is most prevalent in orchards where irrigation water is allowed to stand or where heavy foliage around the trees holds the moisture to the trunks of the trees. The disease may be carried in irrigation water, or in the water draining through an infected orchard. Therefore, an orchard downhill from an infected area can be easily infected. The fungus is prevalent in all of the irrigated lands in the Yakima Valley (15:18). The disease can be quite troublesome with favorable conditions. The initial invasion is usually at the crown of the roots. As the fungus progresses it rots the bark and then the cambium layer below ground level, producing a visible black stain. If the bark of the trees are continously damp, the disease may girdle the tree in a few weeks. The first above ground

symptoms do not show until the disease is well established, then the leaves of the tree turn pale green, then yellow, or red, and then die. This makes it difficult to control, because the disease can be too far along before above ground symptoms are noticed (3:140). In the later part of the season the foliage turns purple which is a positive identification of the disease (13:131).

Controlling the Disease

The elimination of proper growing conditions for this fungus is necessary to control the disease. Proper drainage of irrigation water will allow the ground to dry out sufficiently to be of some control. Removal of weeds and other foliage around the trunk of the tree allows the tree trunks to dry out. Traces of copper added to the irrigation water or copper sprays applied to the trunks of the trees provide control (15:19). When a tree is found to be infected, the dirt should be removed from around the trunk down to a point just below the infection. In this way the diseased tissue is allowed to dry out. Later the trench around the tree may be filled with a porous material, such as pumice, which will allow constant drainage and drying.

Economic Importance

The cost of keeping the orchard clean depends on the type of equipment used and the amount of foliage to be

removed. Figure 10, shows a roto-hoe, attached to a tractor, which is used to hoe around the tree trunks. The cost of this operation is about $2.00 an hour, not including the value of the tractor. Two hours are required to hoe one acre of trees.

FIGURE 10

ROTO-HOE FOR WEEDING AROUND
THE TREE TRUNKS

Many times the roto-hoe does nothing but wrap tall foliage around the tree trunk instead of cutting it off. The situation is then made worse. The roto-hoe can cause bark injury to the tree trunk where bacterial infections or insect attack can take place.

Figure 11, shows an infected trunk that is recovering from crown rot without any treatment other than exposing the crown below the point of infection and allowing it to dry. More trees could be saved in this manner if the disease were easier to detect. When weather conditions such as heavy rains persist during the growing season the whole orchard should be checked frequently for signs of wilting.

FIGURE 11

EXPOSED TRUNK SHOWING
CROWN ROT EFFECTS

Figure 12, shows the extensive pruning done to allow the tree to make a faster replacement of the diseased

tissue. Pruning to this degree results in a certain amount of crop loss, which would be difficult to evaluate. The greatest danger from crown rot is the destruction of trees. A full bearing apple orchard is valued at $2,000 per acre (24:5).

FIGURE 12

EXTENSIVE PRUNING AFTER
CROWN ROT ATTACK

Phytophthora fruit rot is another disease caused by the fungus Phytophthora cactorum. This disease produces a brown and black mold on near ripened fruit. In some seasons it is necessary for pre-harvest spraying to control this disease. Zineb is applied at the rate of eight pounds

per acre, at thirty day intervals after time of infection. Very little spraying has been necessary in recent seasons, however, farmers have been warned that the disease has made its appearance on pears this season (19:1).

Historical

Crown rot has long been a resident of the Yakima Valley, but the cause of the disease was not established till 1939 (13:132). The 1962-63 seasons were extremely wet during the winter and spring months, which set the stage for an unusual amount of infection in the Wapato area (1:10). British Columbia has had a great deal of trouble with crown rot in the last ten years (13:131).

CHAPTER VI

CORYNEUM BLIGHT

During the past few years this disease has spread over most of the Yakima Valley and the farmers are becoming increasingly aware of its economic importance.

Cause and Effects

The fungus disease known as Coryneum blight is caused by the fungus Coryneum Beijerinkii. The stone fruits are the hosts of this disease. Shot hole, and peach blight are some early common names given to Coryneum blight.

Conidia of the fungus attack leaves, fruit, bud, and twigs of the tree. The conidium secrete a sheath to anchor itself to the leaves. Upon germination, tubes grow out from one or more of its cells. Peg like hypha grow down from the germ tubes and penetrate through the cuticle layer. Mycelium growing from the hypha progress between the walls of the host and thus established the disease in the leaf. Masses of hyphal cells form which emerge up through the cuticle and give rise to conidiophores.

Sprinkler irrigation plays a large roll in spreading the disease in a tree, by washing the conidia down the tree to the lower branches, where the heaviest infection is usually seen. Optimum growth is observed at temperatures of 72°F. accompanied by high humidity (21:707). Under favorable

conditions the disease can quickly cause heavy fruit loss. It can kill young fruit trees, especially peach trees (18:25). In figure 13, is a six year old peach tree at mid-season showing probable long term effects of Coryneum blight. The sparse foliage appears small and light green.

FIGURE 13

CORYNEUM BLIGHT EFFECTS
ON PEACH TREE

On the leaves of the tree the disease appears as brown spots with reddish borders. The infected spots on the leaves will later fall out giving a shot hole appearance. This shot hole effect should not be confused with injury due to arsenic sprays. Some bacterial diseases and

also insects will cause shot hole effects in leaves (8:4). The spots on fruit resemble injury due to San Jose scale. These spots are much smaller than those found on the leaves. The spots are purplish red and often have light colored centers. Usually these spots are found only on one side of the fruit (9:11). Figure 14, shows infected fruit and girdled limb from the lower portion of the tree. The spots caused by the fungus are quite apparent on the fruit. The fruit is misshapen and lacks healthy appearance.

FIGURE 14

CORYNEUM BLIGHT ON LIMB
AND FRUIT

Cankers form where the disease invades buds or twigs.

Gumming from these cankers usually appears around the point of infection. Girdling of whole twigs by the cankers kills the twigs. The buds at the point of infection are also killed. Figure 15, shows canker girdling at the bud and the gumming surrounding the canker. Further along the twig is a leaf showing the typical spotting caused by the fungus. The gumming and death of buds on the fruiting wood causes the bark to split on the branches of the current years growth. Bark injuries subject the tree to attack by insects and some bacterial diseases.

FIGURE 15

CORYNEUM CANKER AT THE BUD

The spotting of fruit appears different on cherries.

Just one or two spots are usually found that are brown and without borders. These spots tend to harden and form a callus like growth into the center of the fruit. The shot hole effects of leaves is the same (9:13).

Gumming on the fruit is sometimes evident. Figure 16, shows gum oozing from the Coryneum lesions on the fruit.

FIGURE 16

CORYNEUM BLIGHTED FRUIT SHOWING GUMMING

Controlling the Disease

The control of Coryneum blight is neither difficult nor expensive. Nevertheless, many farmers keep putting off the use of these controls as long as the tree and fruit

damage is slight. In this way the disease is allowed to become well established and more difficult to eradicate. Where well established the disease requires a concentrated three year program to bring the disease under control.

Usually three sprays during the season gives good protection. A spray at the pre-pink stage, at shuck fall, and again in October, before the fall rains gives protection to the young fruit and the tree (18:25).

In sprinkler irrigated orchards the sprinkler heads should be lowered, to prevent the spores being washed down the tree to the lower branches.

Economic Importance

The spray program, outlined above, can be accomplished with the spray material Captan. This is a fifty per cent concentration material. The pre-pink application is at six to ten pounds per acre. Captan fifty per cent wettable powder costs $ .90 per pound, and costs $5.40 to $9.00 per acre. The shuck fall spray, at ten pounds per acre, costs $9.00 per acre. The October spraying is applied at twelve to sixteen pounds per acre, or $10.80 to $14.40 per acre. The cost of application is in addition to these spray materials. In cases where the infection is severe and the treee year program is followed, very little of the fruit is marketable. This points up the desirability of a yearly spray program to insure against heavy crop loss.

Historical

The fungus disease Coryneum blight has been recognized for more than one hundred years. First reports of the disease came from France in 1843, where it was attacking peach trees. By 1900 the disease was found in California, and later became known as California blight (10:33). From 1900 to this time, the disease has spread to most parts of the world where stone fruits are grown (2:98).

CHAPTER VII

VERTICILLIUM WILT

Verticillium wilt is becoming more common on stone fruits of the Wapato area. The 1962 and 1963 seasons saw a rapid rise in the infection of cherry trees. Great concern has been expressed by both farmers and County Extension Agents over the increase in occurance of the disease and the lack of control programs.

Cause and Effects

Verticillium wilt is a soil inhabiting fungus, which attacks through the roots of host plants. The disease is believed caused by the fungus Verticillium albo-atrum and V. dahliae. Some writers consider both organisms to be the same (4:1).

Once the roots have been invaded the fungus advances upward into the main branch or branches of the tree. On many smaller trees the entire tree seems to be invaded.

The effects of the disease are believed to be caused by plugging of the water conducting tissue or toxic materials from the fungus or both (4:1). The first appearance of the effects show as a sudden wilt, on part or all of the branches of the tree. Figure 17, shows a previously healthy eight year old Bing tree in sudden wilt. Some of the leaves on indiviual uprights are

beginning to yellow and curl. The yellowed leaves may either fall or remain until regular leaf fall. The spurs on these infected uprights will be killed.

FIGURE 17

WILTING DUE TO VERTICILLIUM WILT

Some investigators have advanced the idea that over-watering during hot weather may help bring on the disease (4:7). Others have stated that forcing the growth by excessive applications of nitrogen fertilizers puts too much stress on the tree and helps bring on the disease. Some of the growers interviewed by this writer, who suffered losses last year in their cherry orchards have taken note of these new ideas. They have eliminated

excessive use of water and fertilizer; but so far they have not been convinced that it has been of value, though new infections are less than last year.

Figure 18, shows a two year old Bing tree with complete wilting and yellowing. Trees showing this amount of infection will be removed.

FIGURE 18

SEVERE INFECTION CAUSING
DEATH OF THE TREE

The grower of the ten acre plot where this tree was observed removed twenty-six trees in the 1963 growing season. The grower was at a loss to explain how Verticillium wilt could be in the soil, since this land

had never been under cultivation. The answer to this could be the presence of certain weeds that are also hosts to Verticillium wilt. Weeds such as sheppard's purse and pigweed are two hosts that are quite common in open fields. Truck garden crops such as tomatoes, melons, cucumbers, and potatoes are other hosts for the disease. Some of the cherry orchards investigated for this study are planted on former truck garden lands.

Figure 19, is of an eight year old Bing tree showing several dead uprights and the remainder of the tree appearing normal.

FIGURE 19

SECOND YEAR CHARACTERISTICS
OF VERTICILLIUM WILT

The experiment station at Prosser has recommended that manure from livestock that have been fed potatoes not be used in stone fruit orchards. Other conditions favoring wilt are soils that are neutral or slightly alkaline. Most of the orchard soil in Central and Eastern Washington are of this type. Temperatures ranging from 75° F. to 86° F. are favorable for rapid growth of the fungus (4:6).

Figure 20, shows a four year old Bing tree, that has been tagged for removal. This tree was infected

FIGURE 20

SOME SECOND YEAR RECOVERY
FROM VERTICILLIUM WILT

during the 1963 season and shows partial recovery. Most

of the spurs on the uprights are dead except at the very top of the tree. Figure 19, page 37, and figure 20, page 38, show typical second year characteristics of the disease.

Controlling the Disease

There is no satisfactory control of Verticillium wilt in affected trees. Severely infected trees will not recover enough to be economically usuable. Some work has been done with soil fumigants, but so far it has proved too costly to be in widespread use (4:7).

Economic Importance

In this study two ten acre plots of eight year old Bing trees and two ten acre plots of four year old Bing trees were investigated. Figure 21, shows a section of one ten acre plot. There are many lopsided trees resulting from pruning away of infected uprights. Field men had confirmed one hundred per cent infection, in various stages in the two older plots. The two younger plots, according to the grower, show twenty per cent infection and 1963 tree loss of about ten per cent. This grower estimated his loss at $2,000. His estimate was based on assessed valuation. The evaluation of loss does not include loss from this type of pruning. The tree loss in the two older plots investigated was less than five per cent. There is, however, a possibility of losing the complete

orchard. At an assessed valuation of about $3,000 per acre, the total loss might be calculated at $60,000.

FIGURE 21

REMOVAL OF DEAD UPRIGHTS
LEAVING LOPSIDED TREES

Historical

The first definite record of Verticillium wilt was on cherry in 1918, by Van der Lek in Holland. In 1949, Goheen reported the first occurrence of Verticillium wilt of apricot in Washington. Blodgett and Twomey called attention to the disease on cherry, apricot, peach, and prune in Washington in 1955 (4:8).

CHAPTER VIII

POWDERY MILDEW

The apple growers of Washington have had to control powdery mildew for many years. Most home gardeners have seen similar mildew in their flower gardens.

Cause and Effects

Apple powdery mildew is caused by the fungus Podosphaera Leuchotricha. This fungus is an obligate parasite and is absolutely dependent on its host. There are no varieties of apples that are completely immune from powdery mildew.

The fungus is usually first noticed on the surface of leaves, stems, and young fruits. These surfaces will be spread with a white felt like mycelium that absorb their food from the underlying cells. The fungus produces two kinds of spores, conidia or summer spores, and ascospores or overwintering spores.

When the fungus has been established on the surface of any part, the hypha give rise to numerous upright branches which form chains of conidia. The conidia soon break off at the ends of the chain and soon cover the affected parts producing a powdery appearance. Each of these upright branches or conidiaphores has unlimited

power of spore production, so the infection on one leaf will produce tremendous number of conidia. Conidia can be carried by the wind or other agents, and so are responsible for rapid local spread of the mildew during early growing seasons (10:577-578).

The mildew attacks terminals and young shoots. Figure 22, is a closeup photograph showing the heavy mycelial growth on the terminal twigs and leaves. The leaves show

FIGURE 22

HEAVY MYCELIAL GROWTH ON TERMINAL TWIGS AND LEAVES

heavy conidia production. Continous spore production will spread the mildew far down the branch and onto adjacent

branches. As the season progresses the mycelium changes color to light brown or tan. The continous removal of nutrients from leaves causes them to wither and curl. This has an undesirable effect on the thriftiness of the tree (10:575). Figure 23, shows terminal infections on four year old Golden Delicious. Terminal infections cause an

FIGURE 23

TERMINAL INFECTIONS SHOWING CURLED AND WITHERED LEAVES

overgrowth of side shoots which gives a stag horn appearance to the limbs (5:110).

When the fruit is attacked an irregular russeting is produced on the surface of the fruit which greatly

decreases its market value. This russeting can be produced by other causes, such as spring freezes, or sulphur scalding from spray applications. Figure 24, shows russeting on an immature Golden Delicious apple.

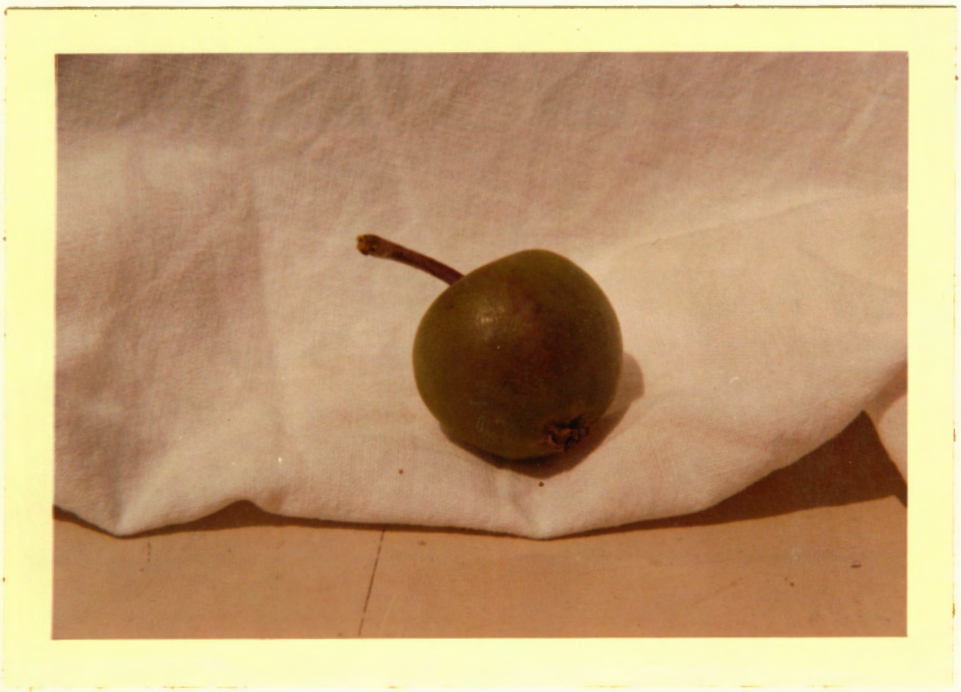

FIGURE 24

RUSSETING ON AN IMMATURE
GOLDEN DELICIOUS

Ascospores, while being the overwintering spores are not the primary source for spring infections. Mycelium of the fungus will overwinter between the bud scales and in the lateral and terminal buds. When the buds open in the spring, the mycelium commences to grow and re-establish itself on new leaves and twigs. This explains the appearance

of mildew when leaves are first out in the spring (10:579).

Controlling the Disease

The control program for powdery mildew consists of four sprays put on during the growing season. The spray is applied at pre-pink stage, again at pink stage, petal fall, and twelve to fourteen days after petal fall. Some growers will apply an additional spray later if the infection is heavy.

Karathane has proven to be a suitable spray until daytime temperatures are 90°F. and above (9:30). Karathane will cause scalding at high temperatures which can be controlled to some extent by reducing the concentration of active material.

Economic Importance

Powdery mildew can cause high cullage rates because of the russeting on the fruit. It also reduces the number of food producing leaves which affects fruit size and finish. The economic loss is evident but difficult to compute on a dollar and cents basis.

Karathane is applied at six pounds per acre. Four applications require twenty-four pounds of material at $1.50 per pound or $36.00 per acre. Applications costs are in addition to this.

In orchards where hand thinning is employed, many

growers have thinners pick off the mildewed terminals as they go along. These are gathered up and burned. Most of the growers interviewed that employed this method, estimated the cost of this control measure at $ .25 per tree or $25.00 per acre with moderate infection. Severe infection could double the cost. Some growers employ chemical thinning and leave these infected terminals on all season.

Historical

Powdery mildew of apples was first recorded in the United States in 1871 (10:574). Rodrick Sprague (16:1) states, "The first useful write up of powdery mildew was a newspaper bulletin issued by the State College of Washington on June 26, 1915."

D. F. Fisher, in 1920, wrote a comprehensive study of apple powdery mildew while at the Wenatchee Station. For many years it was considered the standard source of information (16:1).

A severe powdery mildew epidemic in 1928 was followed by another in 1948. Loss because of the russeting of fruit in 1948 caused the apple industry of Washington to demand a new study to provide better control of mildew (16:2). The re-study is contained in Bulletin 560, published by the Washington State Experiment Stations, April 1955.

The hard winters of 1949 and 1955 reduced or wiped out mildew in many valleys of Central and Eastern Washington. The disease returned to these areas within a few years and the problem is again acute (17:24).

CHAPTER IX

SUMMARY, RECOMMENDATIONS, AND CONCLUSIONS

Summary. The diseases presented in this study can cause untold damage to orchards and fruit. Costs involved in the control of these diseases are variable. They are dependent on weather conditions, control programs, and the financial circumstance of the grower.

The agricultural experiment stations and chemical companies have provided fieldmen, control programs, and continued research to help the fruit grower. With out this help the fruit grower could not survive.

Recommendations. Cooperation is a necessity when two or more groups of people work toward the same ends. Better control of plant diseases would result if (1)growers were better educated in the use of chemicals: (2) better rapport was established between fieldmen and growers.

Conclusions. Additional research and development is needed to stop the continued advance of these fungus diseases. The continued prosperity of the tree fruit industry in this state is contingent with complete control or eradication of these diseases.

BIBLIOGRAPHY

1. Ballard, James K. "Fruit Bowl Comments," Better Fruit, 58:10, June, 1964.

2. Blodgett, Earle C. "Coryneum Blight," Wash. State Hort. Assoc. Proc. 52:98-99. 1956.

3. _____. "Verticillium Wilt, Bacterial Gummosis, and Crown Rot of Cherry," Wash. State Hort. Assoc. Proc. 59:139-140. 1963

4. _____. Verticillium Wilt of Stone Fruits in Washington. 9 pp. Wash. Agr. Exp. Sta. Circ. 425. 1964

5. Compendium of Plant Diseases. Chicago: The Lakeside Press. R. R. Donnelley and Sons Company. 1959. 264 pp.

6. Covey, R. P. "Fire Blight-A Family History and Biography," Washington State Horticulture Association Proceedings 59:137-138. 1963

7. Gravatt, G. F., and D. E. Parker. "Introduced Tree Diseases and Insects," United States Department Of Agriculture Yearbook 1949:446-451 Washington: Government Printing Office 1950

8. Harris, M. R. Diagnosing Plant Diseases. 5 pp. Wash. Extension Mimeograph Circular 2110. Feb. 1961

9. _____. Tree Fruit Diseases. 34 pp. Washington Extension Mimeograph Circular. 2240. Jan. 1963

10 Heald, F. D. Manual of Plant Diseases. New York: McGraw Hill Book Co. 1933, 953 pp.

11. Magness, J. R. "Progress and Needs in Fruit Research," Washington State Horticulture Proceedings 54:23-27. 1958.

12. Martin, J. F., and Perley Spaulding. "Blister Rust on White Pine." United States Department of Agriculture Yearbook 1941:453-458 Washington: Government Printing Office 1950.

13. McIntosh, D. L. "The Collar Rot Problem in Our Orchards." Wash. State Hort. Assoc. Proc. 59:131-136. 1963.

14. Scott, C. Emlen. "Fire Blight of Pears in California," U. S. Dept. of Agr. Yearbook 1953:678-680. Washington: Gov. Printing Office, 1953.

15. Sprague, Roderick. Fungous and Bacterial Pear Diseases of Eastern Washington. 22 pp. Washington State Experiment Stations Circular 413.

16. _____. A Re-study of Apple Powdery Mildew in Eastern Washington. 38 pp. Washington State Experiment Stations General Bulletin 560. 1955.

17. _____. "The Apple Powdery Mildew Control Program for 1957," Wash. State Hort. Assoc. Proc. 52:24-25. 1956.

18. Spray Recommendations for Tree Fruits in Eastern Washington. 36 pp. Washington Extension Bulletin 419, Revised, Jan. 1964.

19. The Wapato Independent, Aug. 20, 1964, p.1.

20. Walker, John C. Plant Pathology. New York: McGraw Hill Book Company, Inc. 1957, 707 pp.

21. Wilson, E. E. "Coryneum Blight of Stone Fruits," U. S. Dept. of Agr. Yearbook 1953:707-710. Washington: Gov. Printing Office. 1953.

22. Wood, Jessie I. "Three Billion Dollars a Year," U. S. Department of Agriculture Yearbook 1953:1-9. Washington: Government Printing Office, 1953

23. Yakima County Agriculture. County Agriculture Data Series. Wash. State Dept. of Agr. 1956. 54 pp.

24. Zuroske, C. H. Washington Apple Production Costs and Labor Requirements. 16 pp. Wash. Agr. Exp. Sta. Bul. 644. 1962